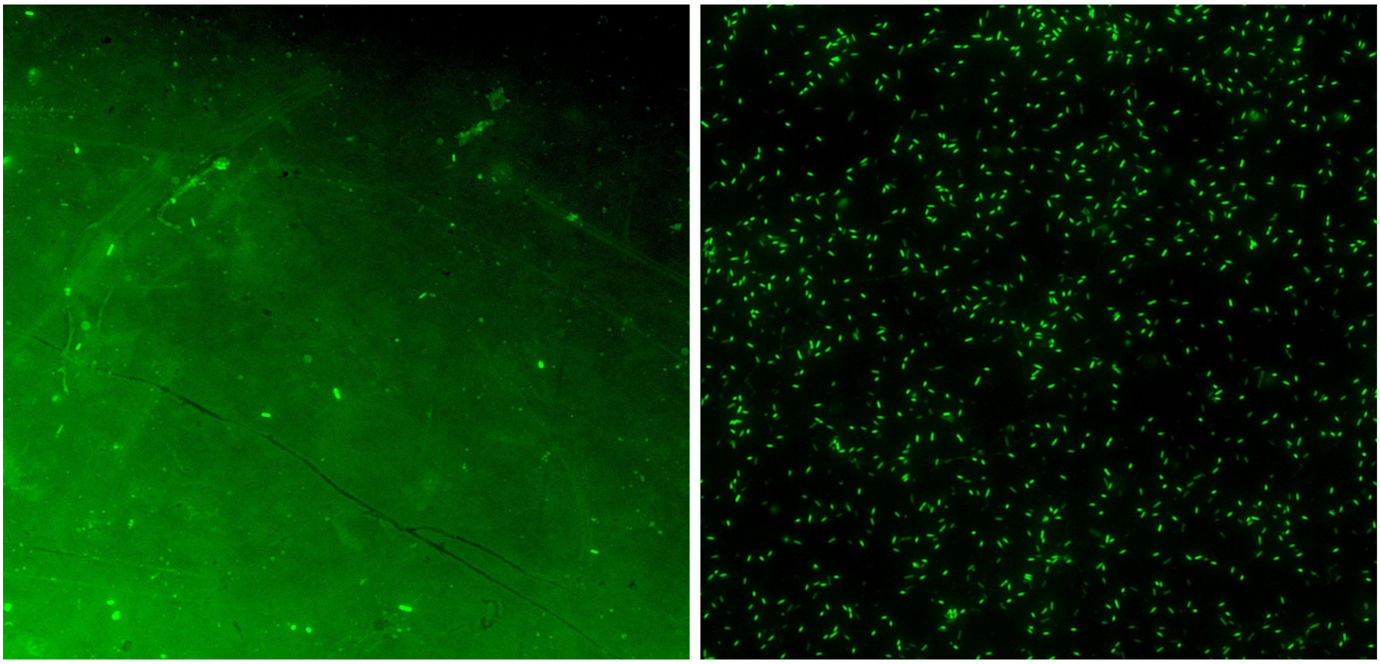
Healthcare industry BW

Polymer brushes with mini proteins protect implants

Patients who have had surgical implants are at risk of developing serious complications due to bacterial infections. This affects around two to six per cent of patients with implants. Scientists from the KIT Institute of Functional Interfaces (IFG) have now succeeded in developing a protective layer that prevents bacteria from adhering to implants and creating dangerous biofilms that can lead to serious infections. The protective layer has proven highly efficient in animal experiments and was also well tolerated by the cells. The findings have now been published in the online edition of the journal "Biomaterials."



Protection: The microscope photos show that much fewer bacteria colonise coated rather than uncoated sections of implants (photo on the left).
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In cooperation with colleagues from the University of British Columbia, the IFG scientists initially screened compounds for their ability to ward off infection when attached to a surface. They used antimicrobial peptides (AMPs), small proteins consisting of a short chain of amino acids. These AMPs are components of the innate immune system and are able to effectively fight off infections: they can kill both Gram-negative and Gram-positive bacteria as well as fungi, viruses and parasites, which means that they have a broad effect.

In a second step, the researchers used polymers to attach peptides with an antibiotic effect to the surface of implants. The construct, which looks like a bottle brush, has several advantages: “The selection of a specifically shaped carrier enabled us to increase the concentration of peptides applied. The immobilisation of the peptides to the carrier also prevents the diffusion of the antimicrobial peptides,” said Dr. Kai Hilpert who is coordinating the project.

Numerous approaches are available to impregnate implants with antimicrobial substances in order to prevent local infections. However, these methods have not been as successful as expected, and some have even been counterproductive. “The diffusion of the antibiotics leads to the generation of a concentration gradient that promotes the bacterias’ resistance to antibiotics,” explains Hilpert. The method is also associated with the risk of developing what is known as adaptive resistance. “The gradient enables the bacteria to adapt to the drug very early on and activate defence strategies, with the result that they survive higher concentrations of antibiotics,” said Hilpert.

The infections are caused by biofilms that develop on the implants when bacteria adhere to and colonise the implant. “The bacteria secrete substances that form a matrix in which the bacteria can grow in a three-dimensional manner. In addition, the bacteria generate a range of specialist genotypes,” said Hilpert. Biofilms, which often consist of a large number of different bacterial species, or different genotypes of a particular species, are far more resistant to antibiotics than small conglomerations of bacteria. The concentrations of antibiotics need to be increased by a 1000-fold in order to destroy bacteria in biofilms. “We were surprised to find that the AMPs used in our construct also prevented the formation of biofilms,” said Hilpert. When the scientists immersed coated pieces of implant into a medium with a high concentration of bacteria, they found that in contrast to uncoated implants, the bacteria did not attach to the coated implants. The researchers have also been able to prove the efficacy of AMPs in animal experiments. Cell culture and rat experiments showed that the protective layer was biocompatible, i.e. did not damage the cells. The researchers have already investigated coatings of titanium surfaces as this material is frequently used for the manufacture of implants. “However, the same principle can also be applied to other surfaces, plastic catheters for example,” said Hilpert.

“The results obtained by Dr. Hilpert and his colleagues open up a new and attractive option for implant coatings. At present, the IFG researchers are focusing on the investigation of the underlying modes of action and on the development of a technological basis for the rapid translation of the findings into clinical settings in order to commence clinical studies in the not-too-distant future” said IFG director Prof. Dr. Christof Wöll highlighting the future prospects.

Press release

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